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EVALUATION OF SINGLE- AND MULTICOLOR MAP AND CHART REPRODUCTION EQUIPMENT

SOUTHWEST RESEARCH INSTITUTE
Post Office Drawer 28510, 8500 Culebra Road
San Antonio, Texas 78284

November 1976

FINAL REPORT

Final Report for period 26 February 1976–1 November 1976
Approved for Public Release; Distribution Unlimited

Prepared for

U. S. Army Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the results of the investigation to determine the ability of state-of-the-art printing technologies to meet the military requirements for a quick reaction/limited quantity map and chart reproduction capability. The processes covered are aimed at meeting the requirements for single and multicolor reproduction. → CONT → (cont'd)

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20. ABSTRACT

These requirements include: input, output, speed and quality of the reproduction, as well as restrictions on size, weight and environmental operating conditions. Covered in this report are the printing technologies which are considered to be the best candidates. Each of the methods are briefly described and the acceptable, marginally acceptable, and unacceptable characteristics as they relate to the military requirements are discussed. Specific additional comments are made about several of the processes and a representative list of manufacturers for each process is included.

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INTRODUCTION AND SUMMARY

This final report covers the results of the investigation to determine the ability of state-of-the-art printing technologies to meet the military requirements for a quick reaction/limited quantity map and chart reproduction capability. The processes covered in this report are aimed at meeting the requirement for single- and multicolor reproduction.

The requirements for the reproduction equipment were set forth in the contract and appear in Appendix A of this report. These requirements include: input, output, speed and quality of the reproduction, as well as restrictions on size, weight, and environmental operating conditions. Covered in this report are the printing technologies which are considered to be the best candidates to meet the requirements of this contract. Such items as letter, gravure, and intaglio presses have not been included because they will not meet a majority of the military requirements for this application.

During the course of this program, 265 companies received copies of the Proposed Military Requirements for Limited Quantity Map/Chart Reproduction Capability. Of those companies, 116 responded either with product information or with letters stating that their respective products were unable to meet most of the specifications. Companies whose products appeared to offer positive input to the program were contacted by telephone or by on-site visits for additional more specific information. The data subsequently received by the project personnel constitute the contents of this final report. It is important to note that, although no given system or process meets all of the needs, a number of them do indeed closely approximate the specifications sought by the Military Requirement listing, especially as it pertains to single-color capability.

There are no commercially available processes which can reproduce a multicolor product which meets the Military Requirements. However, a few systems can or could be modified to reproduce the required multicolor output. Proofing systems, such as Color Key® and Cromalin®, use an overlay technique to simulate color printing but do not qualify as candidates for this study because they are used as single-copy, prepress proofs by the printing reproduction industry.

During the program, multicolor copies of a hydrographic chart were mailed to companies which seemed to have the most promising reproduction capabilities. Eight companies responded by returning a single-color reproduction copy to us for evaluation. These charts were included as a separate data package to this final report. They differ in quality, com-

plexity and cost as is discussed in this report. No company returned a color reproduction of the map which we mailed to them.

Each of the methods covered in this report are briefly described and the acceptable, marginally acceptable, and unacceptable characteristics as they relate to the military requirements for map and chart reproduction are discussed. Specific additional comments are made about several of the processes and a representative list of manufacturers for each process is included.

A relative rating of each of the printing technologies has been made by Southwest Research Institute (SwRI) personnel. This evaluation has been made by using the requirements that appear in Appendix A and the list of the most critical requirements which was forwarded to SwRI and dated 5 March 1976, which appears in Appendix B. The range of values used to rate each of the reproduction techniques are presented in Table 1. Results of this rating evaluation are shown in Tables II and III.

TABLE I. RATING OF PROPOSED MILITARY REQUIREMENTS

A Value Of 0 To 10 Points Was Assigned To Each Of The Following:

Characteristics	Single Color	Multicolor
Input	a. Multicolor products up to 36" x 60" required (42" x 60" desired)	a. Multicolor products up to 24" to 36"
Image Quality	Equal to lithography	Equal to lithography
Output	Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired)	Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color)
Distortion	±0.1 percent (1/16 inch over 60-inch dimension)	±0.1 percent
Start-up time (1st copy)	5 minutes	5 minutes

A Value Of 0 To 6 Points Was Assigned To Each Of The Following:

Characteristics	Single Color	Multicolor
Process	Utilize dry process - dry to dry	Utilize dry process - dry to dry
Printing medium	Regular high wet strength map paper - option dielectric or photoconductive coated paper	Regular high wet strength map paper - option dielectric or photoconductive coated paper

TABLE I. RATING OF PROPOSED MILITARY REQUIREMENTS (cont'd)

A Value Of 0 To 3 Points Was Assigned To Each Of The Following:

Characteristics	Single Color	Multicolor
Length of run	25 minimum copies	10-500 copies
Speed (copies per hour)	60-300	300
Cost	Less than offset (material and labor) for runs up to 25 copies	Less than offset (material and labor) for runs up to 300 copies
Resolution (L/mm)		
a. Input	10 for full size, 150 for 70 mm x 100mm slides	10 for full size, 150 for 70 mm x 100mm slides
b. Output	6	8
Registration	Not applicable	Within 0.005" circle
Scale variation	±.05 percent	±.05 percent
Physical size		
a. Construction	Rugged, readily assembled and disassembled, in about 4-8 hours	Rugged, readily assembled and disassembled, in about 4-8 hours
b. Weight	5000 pounds maximum (2000 pounds desired)	5000 pounds maximum (2000 pounds desired)
c. Size	120 ft^3	540 ft^3 (6' x 6' x 15') (120 ft^3 desired)

TABLE I. RATING OF PROPOSED MILITARY REQUIREMENTS (concl'd)

A Value Of 0 To 3 Points Was Assigned To Each Of The Following:

Characteristics	Single Color	Multicolor
Operating Conditions		
a. Temperature	40-100°F	40-100°F
b. Relative Humidity	10-95 percent	10-95 percent
Input	b. 70mm x 100mm multi-colored slides desired	b. Color separated black and white 70mm x 100mm slides c. Black and white color separations up to 24" x 36"

TABLE II. EVALUATION OF SINGLE-COLOR REPRODUCTION TECHNIQUES FOR PRODUCING LIMITED QUANTITIES OF MAPS AND CHARTS

Characteristics	Range	Litho-graphy Offset	Screen	Diazo	Dry Silver	ASF	Chromium Dioxide	Ink Jet	Electro-static Plotter	Electro-static Copier
1. Input										
a. Multicolor 42 x 60"	0-10	5	5	5	5	5	7	5	5	6
b. 70 mm x 100 mm slides	0-3	1	1	1	2	0	1	1	1	0
2. Output										
Monochrome 42 x 60"	0-10	10	10	7	0	7	10	10	7	5
3. Run										
25 copies min.	0-3	3	3	3	3	3	3	3	3	3
4. Speed										
60-300/hour	0-3	3	1	3	3	1	3	2	0	0
5. Litho. Quality	0-10	10	7	5	5	0	5	5	5	7
6. Cost	0-3	2	0	2	1	2	3	3	3	3
7. Resolution L/mm										
a. Input 10 full 150 slide	0-1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
b. Output - 6	0-1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
8. Registration	--	--	--	--	--	--	--	--	--	--
9. Scale										
±.05%	0-3	3	3	3	0	2	3	3	3	3
10. Distortion										
±0.1%	0-10	10	10	10	0	5	10	10	10	10
11. Accpt. Printing Medium	0-6	6	6	6	6	6	6	6	6	6
12. Start-up Time										
5 minutes	0-10	5	7	10	10	10	10	10	10	10
13. Size										
a. Construction	0-1	0	1	1	1	1	1	0	1	1
b. 5000 lb max.	0-1	0	1	1	1	1	1	1	1	1
c. 120 ft^3 max.	0-1	0	1	1	1	1	1	1	1	1
14. Environment										
a. Temperature	0-1.5	1	1	1.5	1.5	1.5	1	0	1.5	1
b. Humidity	0-1.5	0	0	1.5	1.5	1.5	1	0	1.5	1
15. Dry Process	0-6	3	0	6	6	6	6	3	6	6
TOTAL SCORE	86 max.	65	60	70	50	56	75	66	68	67
% OF MAX. SCORE	--	76	70	81	58	65	87	77	79	78

TABLE III. EVALUATION OF MULTICOLOR REPRODUCTION TECHNIQUES FOR PRODUCING LIMITED QUANTITIES OF MAPS AND CHARTS

Characteristics	Range	Lithography Offset	Screen	Ink Jet	Electrostatic Copier Xerox 6500	Electrostatic Copier EIR
1. Input						
a. Multicolor 24" x 36"	0-10	5	5	5	0	0
b. 70 mm x 100 mm slides	0-3	2	2	2	0	3
c. Separations 24" x 36"	0-3	3	3	2	0	0
2. Output						
Multicolor 24" x 36"	0-10	10	10	10	0	10
3. Run						
10-500 copies	0-3	3	3	3	3	3
4. Speed						
300/hour	0-3	3	0	3	0	0
5. Litho. Quality	0-10	10	5	5	5	5
6. Cost	0-3	2	2	3	3	3
7. Resolution L/mm						
a. Input 10 full	0-1.5	1.5	1.5	1.5	1.5	1.5
150 slide	0-1.5	1.5	1.5	1.5	1	1
b. Output - 8						
8. Registration	0-10	10	5	10	5	5
9. Scale						
±.05%	0-3	3	3	3	3	3
10. Distortion						
±0.1%	0-10	10	10	10	10	10
11. Accpt. Printing Medium	0-6	6	6	6	6	6
12. Start-up Time						
5 minutes	0-10	0	0	10	10	10
13. Size						
a. Construction	0-1	0	1	0	1	1
b. 5000 lb max.	0-1	0	1	1	1	1
c. 540 ft^3	0-1	0	1	1	1	1
14. Environment						
a. Temperature	0-1.5	1	1	0	1.5	1.5
b. Humidity	0-1.5	0	0	0	0	0
15. Dry Process	0-6	3	0	3	6	6
TOTAL SCORE	99	74	61	80	58	71
% OF MAX. SCORE	--	75	62	81	59	72

SINGLE-COLOR REPRODUCTION TECHNIQUES

LITHOGRAPHY/OFFSET

A. Description of Method

With the offset lithography method, the printing surface is on a plane with--or barely raised over--the printing plate. It is typical of this process that the plate does not touch the paper directly but prints by means of an intermediate rubber blanket; hence the term "offset." The oily printing surface is separated from the non-printing surfaces which are moistened with water.

Offset is a common printing method today. Typical examples are advertising circulars, catalogues, etc., but a few newspapers and many house magazines are now also done by offset. The standard procedure for printing large maps is this process.

On paper the typical offset-printed line has a light and even film of ink with no pronounced edges. This quality is, of course, due to the ink having been deposited by a rubber blanket. Because of the rubber blanket, offset impressions are also typically colored in the valleys of the paper surface without undue pressure. (This is also the reason why offset is preferred for printing on textured paper stock). There is never embossing of the paper in offset. Offset printing is commonly done from metal plates of different types. The most common type is the sensitized variety.

B. Acceptable Characteristics to Meet Requirements

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

This is regarded as standard output material.

3. Length of Run

25 minimum copies.

This number of copies is at the low end of the operating range.

4. Speed (copies per hour)

60-300

This speed is at the low end of the operating range.

5. Image Quality and Color Fidelity

Equal to lithography.

This method is obviously equal to lithography.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

b. Output

6

This is very easily attainable.

9. Scale Variation

±.05 percent.

This scale variation is within tolerances for standard printing presses.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

This parameter is easily met if a dimensionally stable medium is used.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This type of paper presents no real problem when used with a standard offset printing press.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

This method requires a good deal of equipment, i.e., camera, copyboard and a platemaker, and time to process the material.

b. 70 mm x 100 mm multicolored slides desired.

This method also requires about the same supportive equipment of a 15X enlarger and platemaker, and time to process the material.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

Actually this method is equal to and not less than offset cost (see E. Comments).

12. Start-up Time (1st copy)

5 minutes.

Even with the printing press prepared ahead of time, the first copy would probably require approximately 10 minutes to print.

15. Process

Utilize dry process - dry to dry.

The offset method uses ink and solution to repel ink in areas not be printed thereby rendering this a wet method.

D. Unacceptable Characteristics to Meet Requirements

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Printing presses are much too large and complex to disassemble and then reassemble in 4-8 hours.

b. Weight

5000 pounds maximum (2000 pounds desired).

Printing presses in the size range required have a standard average weight of about 10 tons.

c. Size

120 ft^3.

Printing presses in the size range required are about 1000 ft^3.

14. Operating Conditions

a. Temperature

40° - 100°F

Printing ink and most papers do not respond well to extreme temperatures.

b. Relative Humidity

10 - 95 percent

Again, printing ink and most papers do not respond well to extreme humidity.

E. Comments

Proof presses have similar characteristics as those listed above except that they are smaller (300 ft^3), lighter (9000 pounds) and have a correspondingly smaller printing image area (27" x 39" being the biggest commercially available proof press we have found).

Depending upon the quality of output desired, a multicolored map can go through a number of color separation steps to translate it to single-color output. Costs can subsequently range from approximately $200.00 to $1400.00.

F. Representative List of Manufacturers

Baker-Perkins Printing Machinery Corp.
492 W. Wrightwood Avenue
Elmhurst, IL 60126

Consolidated International Corporation
Chicago, IL 60609

Harris-Seybold Company
Cleveland, OH 44105

Heidelberg Eastern, Inc.
Glendale, L.I., NY 10037

MGD Graphic System
2011 W. Hastings
Chicago, IL

Royal Zenith Corporation
2101 Jericho Turnpike
New Hyde Park, NY 11040

Solna Corporation
50 Lafayette Place
Kenilworth, NJ 07033

SCREEN

A. Description of Method

"Screen process is distinguished by several technical characteristics. Of these the following six are mentioned: (1) Screen process is the only printing method in which hand printing is still found practical and where hand printing is used side-by-side with printing on mechanical presses. (2) Screen process achieves image transfer with exceptionally low pressure. (3) Inking is done in screen process as part of image transfer whereas in other printing methods inking precedes the act of image transfer. (4) The inking apparatus is not only of the simplest, it is also part of the image carrier, whereas other printing methods require more or less complex independent inking systems. (5) The printed ink film can be extremely thick; it is normally much thicker than ink films in letterpress and offset lithography. (6) In consequence of the heavy ink films, screen-process printing requires individual drying of printed sheets before they can be piled.

"The thickness of the ink film can be a most important appearance characteristic of screen process; screen-process prints show exceptionally strong colors. It is even possible to print enamels and to evoke the effects of embossed images by screen process."*

B. Acceptable Characteristics to Meet Requrements

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

This is regarded as standard output material.

3. Length of Run

25 minimum copies.

This number of copies is at the low end of the operating range.

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*Victor Strauss, The Printing Industry, Printing Industries of America, Inc., pp. 41-42, 1967.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

b. Output

6

This is very easily attainable.

9. Scale Variation

±.05 percent.

This scale variation is within tolerances for standard equipment.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

This parameter is easily met if a dimensionally stable medium is used.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This type of paper presents no real problem when used with this process.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

Typical average weight is approximately 750 pounds.

c. Size

120 ft^3.

Typical size is approximately 120 ft^3 for a silk screen press having an image area of 42" x 60".

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

This method requires a good deal of equipment, i.e., camera, copyboard and screen preparation equipment.

b. 70 mm x 100 mm multicolored slides desired.

This method also requires about the same supportive equipment of a 15X enlarger and screen processor.

4. Speed (copies per hour)

60-300

This method is good only up to approximately 100 copies per hour and that does not include drying time required.

5. Image Quality and Color Fidelity

Equal to lithography.

Only under ideal conditions and with a highly trained operator could this method meet lithographic quality.

12. Start-up Time (1st copy)

5 minutes.

This time requirement could be met.

14. Operating Conditions

a. Temperature

40° - 100°F

Printing ink and most papers do not respond well to extreme temperatures.

D. Unacceptable Characteristics to Meet Requirements

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

This method of printing is expensive when the cost of the screen and its processing is considered

14. Operating Conditions

b. Relative Humidity

10 - 95 percent

Again, printing ink and most papers do not respond well to extreme humidity.

15. Process

Utilize dry process - dry to dry.

This is a wet printing method.

E. Comments

It is questionable that this process would be an acceptable technique for reproducing maps in the fields because of the complexity of reproducing accurate screens and the fact that a wet print that must be dried is produced.

F. Representative List of Manufacturers

Atlas
1733 Milwaukee Avenue
Chicago, IL 60647

Joseph E. Podgor Co., Inc.
P. O. Box 1714
Philadelphia, PA 19105

DIAZO

A. Description of Method

The diazo process requires that a translucent original and a sheet of sensitized material are fed into the exposure section where both pass around a revolving cylinder containing the exposure lamp. Ultraviolet light from this lamp passes through the non-image areas of the original, deactivating (burning away) all coating on the copy sheet except those portions blocked out by the image on the original. Protected areas are the latent copy image--exposed but undeveloped. The sheets are then automatically separated--the original returning to operator; the copy sheet continuing to the developer section. Here the latent image is developed through contact with continuously circulating ammonia vapors or with a citric acid and bromythymol blue sodium salt absorber powder. The result is full-size copy of the original.

B. Acceptable Characteristics to Meet Requirements

3. Length of Run

25 minimum copies.

This number of copies is at the low end of the operating range.

4. Speed (copies per hour)

60-300

This process is within the operating range.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

9. Scale Variation

±.05 percent

This scale variation is within tolerances for standard equipment.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

Using a vacuum frame light table printer.

12. Start-up Time (1st copy)

5 minutes.

There is no problem meeting this time requirement.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

Typical approximate weight is under 2000 pounds.

c. Size

120 ft^3.

Typical approximate size is in a range from 30 ft^3 to 280 ft^3.

14. Operating Conditions

a. Temperature

40 - 100°F

Temperature is not a problem with this method.

b. Relative Humidity

10 - 95 percent

Humidity is not a problem with this method if a stable coated paper is used.

15. Process

Utilize dry process - dry to dry.

This method discharges dry copy from the system.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

Process requires that a translucent copy of original be made.

b. 70 mm x 100 mm multicolored slides desired.

Process requires that a 15X enlarger be used and a translucent copy is required as the contact original.

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

Monochrome products can be produced exclusive of overprinting because of the coated paper being used for printing.

5. Image Quality and Color Fidelity

Equal to lithography.

It is believed that the quality is something slightly less than that of lithography.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

This process is less than offset only within a limited range.

7. Resolution (L/mm)

b. Output

6

The output resolution is less than 6 but believed to be acceptable.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This paper must be coated with the proper chemicals before it can be processed by this method.

D. Unacceptable Characteristics to Meet Requirements

None for this printing method.

E. Comments

This process has been used for a number of years to reproduce engineering drawings and other large documents. Recent developments which allow for the reproduction of undistorted blow-backs from small aperture cards appear to make this system a viable process for map and chart reproductions.

F. Representative List of Manufacturers

Blu-Ray, Incorporated
25 Westbrook Road
Essex, CT 06426

Bruning Division Addressograph Multigraph Corporation
1834 Office Square
Schaumburgh, IL

GAF Corporation
Office Systems Div.
140 West 51st Street
New York, NY

Keuffel & Esser
20 Whippany
Morristown, NJ 07960

DRY SILVER

A. Description of Method

This process uses a dry silver coated paper which is then printed by a Reader/Printer system. Typically the input to this type of system is 16 mm and 35 mm reel film or 35 mm aperture cards which contain an amount of information equivalent to an "E" size engineering drawing. The system has a large screen for full viewing of the entire image and a print button will serve to generate a hard copy, full-size print. Lens magnification in the system works at a setting of typically 15X; however, some output distortion is encountered during blow-back.

B. Acceptable Characteristics to Meet Requirements

3. Length of Run

25 minimum copies.

This number of copies is at the low end of the operating range.

4. Speed (copies per hour)

60-300

Typically this equipment will print approximately 240 copies per hour.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

b. Output

6

This is very easily attainable.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This paper must be coated with dry silver before it can be processed by this method.

12. Start-up Time (1st copy)

5 minutes.

There is no problem meeting this time requirement.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

Typically approximate weight is 850 pounds.

c. Size

120 ft^3.

Typical approximate size is 30 ft^3.

14. Operating Conditions

a. Temperature

40 - 100°F

The temperature operating range for this equipment is 32° to 105°F.

b. Relative Humidity

10 - 95 percent

The humidity range for this equipment is 10 to 95 percent.

15. Process

Utilize dry process - dry to dry.

This method discharges dry copy from the system.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 70" desired).

Original input must be reduced by camera as supportive equipment to fit the aperture card.

b. 70 mm x 100 mm multicolored slides desired.

Commercially not available to accept 70 x 100 mm input to the system. There are some special units produced for the U. S. Army and Navy that will accept 70 mm film

5. Image Quality and Color Fidelity

Equal to lithography.

It is believed that the quality is something slightly less than that of lithography.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

This process is less than offset only within a limited range.

D. Unacceptable Characteristics to Meet Requirements

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

The largest, commercially available size located to date is only 18" x 24".

9. Scale Variation

±.05 percent.

This percent tolerance is not within the current state-of-the-art capability.

10. Distortion

±0.1 percent (1/16 inch over a

This percent tolerance is not within the current state-of-the-art capability.

E. Comments

This process is proprietary with the 3M Company. It is basically a photographic process in which the development is done automatically in dry copies up to 18" x 24" which can be produced on commercially-available equipment. The major restriction with respect to increasing the size of this equipment would be the distortion which would develop from the lens arrangement (which might be correctable) and the cost of materials associated with this process. This system as it presently stands could not be used to reproduce copies from full-size originals.

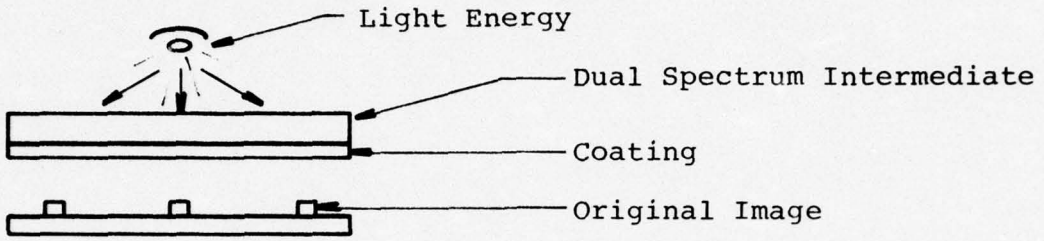
F. Representative List of Manufacturers

3-M Company
3-M Center
St. Paul, MN 55101

APERTURED SPECTRAL FLUORESCENCE (ASF)

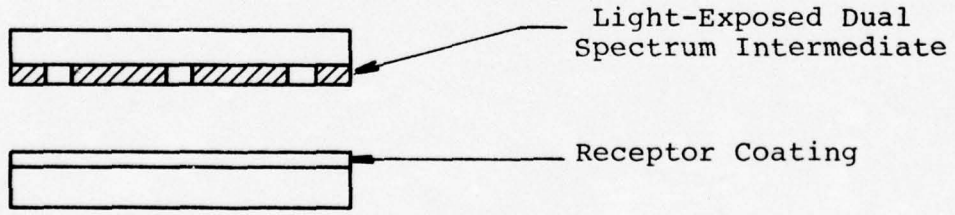
A. Description of Method

Exposure: The Dual Spectrum intermediate is placed coated side against the image of the original and the two sheets are firmly pressed together during a light exposure step at a speed of about ten feet per minute.



Development: After exposure to light the intermediate sheet is removed from the original and placed, coated side down, against a sheet of Dual Spectrum receptor paper.

The two sheets are pressed together in a roll heating device (approximately 250°F) at a speed of about 10 feet per minute. A reactant is sublimed from the intermediate to the receptor coating to form a permanent, blue-black image corresponding to the original image.



Mechanism: The exposure mechanism is a typical, dry reflex system. Light of the proper wave-length passes through the intermediate sheet and strikes the original to be copied. In the background areas, the light is reflected back through the intermediate. The combination of two passes of light, incident and reflection, is sufficient energy to desensitize the intermediate coating. (Dark areas in the above).

The light which passes through the intermediate and strikes the image of the original is absorbed and diffused. Thus there is insufficient energy available, without good reflection, to densensitize this area of the intermediate (light areas in the above).

During the heating step (development), the non-desensitized reactants are sublimed to the receptor coating causing a reaction to occur in the receptor coating which corresponds to the original image.

B. Acceptable Characteristics to Meet Requirements

3. Length of Run

25 minimum copies.

This system will meet this number of copies without difficulty.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

This system costs less than offset within a limited number of copies.

7. Resolution (L/mm)

a. Input

10 for full size.

This input resolution is standard.

b. Output

6

This system has a minimum of 4 and a maximum of 7 L/mm.

11. Printing Medium

Regular high wet strength map paper-option dielectric or photoconductive coated paper.

Precoated high-strength map paper can be used with this system.

12. Start-Up Time (1st copy)

5 minutes

There is no problem meeting this time requirement.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

The approximate weight is 1000 pounds.

c. Size

120 ft^3.

Approximate size is less than 20 ft^3.

14. Operating Conditions

a. Temperature

40 - 100°F

The temperature operating range for this equipment is acceptable.

b. Relative Humidity

10 - 95 percent

The humidity range for this equipment is acceptable.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

This is regarded as standard input material with the exception that the system reads the color yellow as white.

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

Monochrome products can be produced with the exception of overprinting.

4. Speed (copies per hour)

60 - 300

This system might achieve a top printing speed of 60 copies per hour.

9. Scale Variation

±.05 percent.

It is not known by the manufacturer for certain if this system can meet this criterion.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

It is not known by the manufacturer if this system can meet this criterion.

D. Unacceptable Characteristics to Meet Requirements

1. Input

b. 70 mm x 100 mm multicolored slides desired.

This system cannot use slides as input because it has no blow-back capability.

5. Image Quality and Color Fidelity

Equal to lithography.

This system does not meet even the low end of litho output quality.

E. Comments

The ASF Dual Spectrum machine to accept up to "E" size engineering drawings (34" x 44") was on display at the Colorado Springs IRGBA show.

F. Representative List of Manufacturers

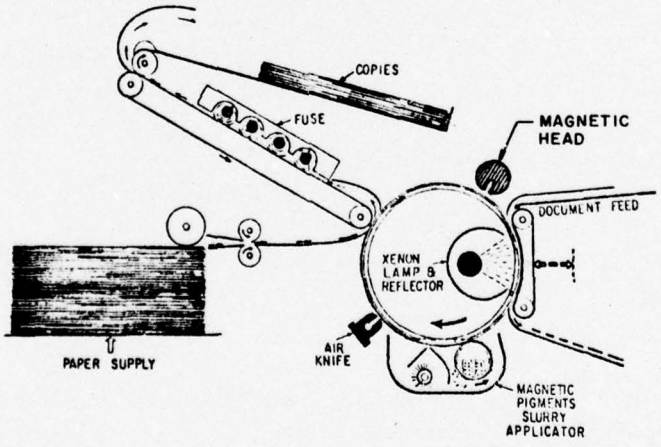
3-M Company
3-M Center
St. Paul, MN 55101

CHROMIUM DIOXIDE

A. Description of Method

Chromium dioxide (CrO_2) has a low Curie point (116°C) which makes it practical to use radiant energy as an imaging method. One procedure by which CrO_2 can be used to produce duplicate copies of a document is illustrated in the figure below. A film of CrO_2 is attached to the outside surface of a transparent glass drum. The CrO_2 film is easily magnetized, while cool, with a weak magnetic field. The original document is exposed to a high-intensity Xenon lamp as it passes over a non-rotating reflector aperture in contact with the surface of the drum. The white areas of the document reflect the light and demagnetize adjacent CrO_2 particles by heating them past the Curie point. The image is decorated with dry magnetic toner particles. An air knife is used to strip off background and return excess toner to the toner applicator. The image is transferred electrostatically to the copy paper. The transferred image is fixed to the paper by fusion. The latent image formed is permanent, until a weak magnetic field is applied to the system for erasing.

EXPERIMENTAL MACHINE



B. Acceptable Characteristics to Meet Requirements

1. Input

   a. Multicolored products up to 36" x 60" required (42" x 60" desired).

The process has been demonstrated with 36" wide transparency input. To input multicolored opaque products will require either a scan technique (preferable) or development of a 36" wide semi-transparent, reflex member.

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

The 42" wide output appears to be within acceptable limits. The 36" wide samples have been run in the laboratory.

3. Length of Run

25 minimum copies.

The image from a single exposure is permanent until erased and life is determined only by wear of CrO_2 surface. Laboratory results indicate life at least in the ten thousand to one hundred thousand copy range.

4. Speed (copies per hour)

60-300

300 copies/hour within present speed.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

May be less than offset because the master is reusable and no skilled labor is required.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

Reflex system can handle full size document, the resolution from a slide depends on the scanner used.

b. Output

6

6 L/mm should be easily attainable.

9. Scale Variation

±.05 percent.

Since a contact image can be made with this system, no problem in meeting this requirement is expected.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

Since a contact image can be made with this system, no problem in meeting this requirement is expected.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Regular high wet strength map paper can be run on this machine.

12. Start-up Time (1st copy)

5 minutes

Approximately one minute required for first copy.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Should be easily set up and in operation in 4-8 hours.

b. Weight

5000 pounds maximum (2000 pounds desired)

Estimated weight approximately 2000 pounds.

c. Size

120 ft^3.

Estimated at 120 ft^3.

14. Operating Conditions

a. Temperature

40° - 100°F

Since the machine is self-contained it will operate within this range.

15. Process

Utilize dry process - dry to dry.

This system is dry to dry.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

b. 70 mm x 100 mm multicolored slides desired.

A scanner will have to be incorporated with the unit in order to handle slides.

5. Image Quality and Color Fidelity

Equal to lithography.

Approaches the low end of litho quality.

12. Start-up Time (1st copy)

5 minutes.

It will probably take 5 to 10 minutes to obtain an image from a 70 mm x 100 mm slide.

14. Operating Conditions

b. Relative Humidity

Very low humidity may cause some problems with the system.

D. Unacceptable Characteristics to Meet Requirements

None for this printing method.

E. Comments

This system is in the engineering prototype stages and not in production, however it does appear to be a reasonable candidate system for the Military Requirements for a Limited Quantity Map/Chart Reproduction Equipment.

F. Representative List of Manufacturers

E. I. DuPont
1007 Market Street
Wilmington, DE 19898

INK JET

A. Description of Method

Two principles of physics are used in the ink jet printing technology. The first principle, known as Raleigh breakup, recognizes that jets of liquid are basically unstable and will break up into uniform sized and spaced droplets at a preferred frequency. The second principle is that these droplets can selectively be electronically charged.

The Dijit system developed by Mead Digital System, Inc., combines these two basic principles to generate and direct minute ink droplets towards a moving web of paper and control them to form desired, programmed images on the paper as it speeds past a parallel array of ink jets.

The microscopic ink droplets are created by forcing an ink stream through a small orifice under high pressure. In doing so, the basically unstable ink stream follows its natural inclination to break into random droplets. To overcome the non-uniformity of these droplets, the system exposes the jet streams to a preferred ultrasonic frequency at which the droplets break up into uniform droplets.

These droplets are then channeled through cylindrical electrodes. By applying an electrical potential between the electrodes and the ink jet streams, a charge can be applied to each drop. On command of the data system (computer), the electrodes are switched between ground and an electrical potential. This permits the selective charging of droplets.

The charged and non-charged droplets are then passed through a high voltage field. Charged droplets are deflected and collected in a grounded "catcher" and are pumped back to the ink reservoir. Uncharged drops continue to the paper surface to form printed images.

B. Acceptable Characteristics to Meet Requirements

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

Can presently produce full size copies.

3. Length of Run

25 minumum copies.

Yes, the original can be scanned each time to eliminate a computerized memory system.

4. Speed (copies per hour)

60-300

120 to 180 copies likely with present system.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

Cheaper because no plate is required.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This is easily accomplished with the proper scanner.

b. Output

6

10 L/mm are claimed to be obtainable with 578 jet unit.

9. Scale Variation

±.05 percent.

The system should be able to stay within this range.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

The system should be able to stay within this range.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Yes, almost any substrate is acceptable.

12. Start-up Time (1st copy)

5 minutes.

1-1/2 to 2 minutes is normal start-up time.

13. Physical Size

b. Weight

5000 pounds maximum (2000 pounds desired).

Approximate weight is 2000 pounds.

c. Size

120 ft^3.

Approximate volume <120 ft^3.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

An optical scanner required.

b. 70 mm x 100 mm multicolored slides desired.

An optical scanner required.

5. Image Quality and Color Fidelity

Equal to lithography.

Approaches lower end of litho.

15. Dry Process

Utilize dry process - dry to dry.

This system delivers output which is almost completely dry when completed.

D. Unacceptable Characteristics to Meet Requirements

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

The system cannot be set up within 4-8 hours.

14. Operating Conditions

a. Temperature

40°F - 100°F

60^{o} - 90^{o}F normal operating range.

b. Relative Humidity

10 - 95 percent

Low humidity required at high temperature in order for equipment to run properly.

E. Comments

Ink Jet printing is primarily being developed by two major companies in this country; Mead Digital System, Inc. and Gould, Inc. Two additional companies, A. B. Dick and IBM, are presently marketing Ink Jet equipment which is limited to alpha numeric printing. It appears that only the Mead system is capable of producing reproductions in the size and at the rate required.

F. Representative List of Manufacturers

A. B. Dick Company
5700 W. Toughy Avenue
Chicago, IL 60648

Gould
3631 Perkins Avenue
Cleveland, OH 44110

IBM
11400 F.M. Road 1325
Austin, TX 78759

Mead Digital System, Inc.
1368 Research Park Drive
Dayton, OH 45432

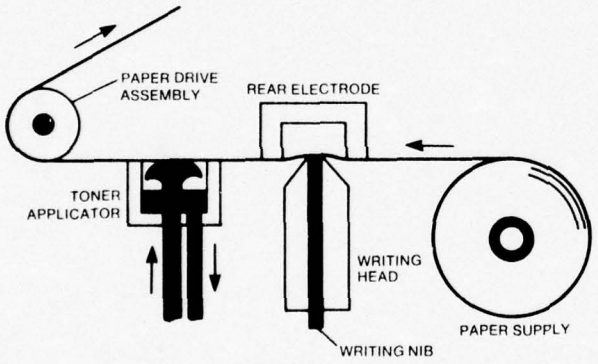
ELECTROSTATIC PLOTTER

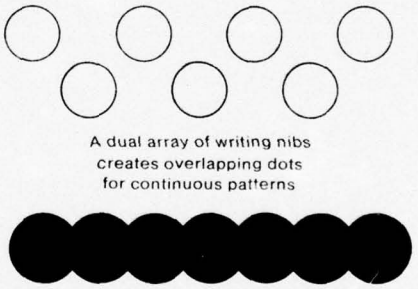
A. Description of Method*

Speed, reliability, and low cost of electrostatic plotting is now available in new wider formats, up to 72 inches wide. They plot with electronic reliability--no mechanical arms or pens; no skips or overshoots. Programmed voltage is applied to an array of densely spaced writing nibs embedded in a stationary writing head. Upon digital command, the nibs selectively create minute electrostatic dots on the paper as it passes over the writing head. The paper is then exposed to liquid toner to produce a visible permanent image

As paper emerges from the unit, the output is immediately ready to distribute and use. No special handling is required. The paper is insensitive to light and is reproducible on office copiers. Translucent paper output may be reproduced on diazo type machines.

Operating principle of Electrostatic units





B. Acceptable Characteristics to Meet Requirements

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

This is regarded as standard output, with the exception that the coated paper necessary for the system can not be overprinted.

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*Information taken from a product information brochure published by Versatec, Santa Clara, California.

3. Length of Run

25 minimum copies.

This number of copies is at the low end of the operating range.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

9. Scale Variation

±.05 percent

This scale variation is within standard tolerances.

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

This parameter is easily met if a dimensionally stable medium is used.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This type of paper presents no real problem when coated with proper chemicals.

12. Start-up Time (1st copy)

5 minutes.

There is no difficulty meeting this time requirement.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

Approximate weight for this equipment is 700 pounds, plus computer and support equipment.

c. Size

120 ft^3.

Approximate size for this equipment is 120 ft^3.

14. Operating Conditions

a. Temperature

40° - 100°F

The temperature operating range for this equipment is 32° to 105°F.

b. Relative Humidity

10 - 95 percent

The humidity range for this equipment is 10 to 95 percent.

15. Process

Utilize dry process - dry to dry.

This method discharges dry copy.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

Supportive equipment is somewhat extensive, i.e., scanner, computer and interface and tape drive.

b. 70 mm x 100 mm multicolored slides desired.

Supportive equipment is somewhat expensive, i.e., scanner, computer and interface and tape drive.

5. Image Quality and Color Fidelity

Equal to lithography.

The quality is something slightly less than that of lithography.

6. Cost

Less than offset (material and labor) for runs up to 25 copies.

This process is less than offset only within a limited range.

7. Resolution (L/mm)

b. Output

6

The output resolution is 4 which may be acceptable.

D. Unacceptable Characteristics to Meet Requirements

1. Speed (copies per hour)

60-300

This equipment will produce approximately 45 copies per hour.

E. Comments

The electrostatic plotter requires interfacing with computers. This is a major drawback of the system because of the additional equipment cost and added complexity of the system; however, it does add the capability of being able to transmit data from a central location to a number of remote printing facilities.

F. Representative List of Manufacturers

Dicomed Corporation
9700 Newton Avenue
Minneapolis, MN 55431

Gould
3631 Perkins Avenue
Cleveland, OH 44110

Oce
6500 North Lincoln Avenue
Chicago, IL 60645

Versatec
(Data Mkt.)
2805 Bowers Avenue
Santa Clara, CA 95051

ELECTOSTATIC COPIER

A. Description of Method

Electrophotography or xerography is based on the photoelectric properties of certain materials. (Photoelectric materials change their electric conductivity under the influence of light). If a xerographic surface is charged and then exposed to light the areas hit by the light lose their charge whereas the non-illuminated areas retain it. The result of exposure is an invisible latent photoelectric image. This image is made visible by treating the exposed surface with a medium containing colorants whose particles have the opposite electric charge. Generally speaking, photoelectric receptors are negatively charged, colorant particles have a positive charge." Two processes that are based on this principle are Xerox photocopying and electrophotography on paper.

"In Xerox photocopying equipment the photoelectric material is a thin layer of selenium on a conductive plate or drum. This plate is first electrically charged, then exposed, and the resulting invisible, latent, image is made visible by development with a dry powder containing a silica base coated with plastic combined with a colorant, carbon black, for example. The toner has a negative charge and adheres to the latent image on the selenium photo conductor which has a positive charge. Since the selenium plate or drum is part of the equipment, the developed image is transferred to paper, and because the dry particles can be easily displaced, the plastic coated powder is fused to the paper by heat or solvent vapor treatment.

"The substrate material for electrophotography on paper, as practiced in the RCA Electrofax Process and others, is coated with a formula containing dye-sensitized zinc oxide in a resin binder. (Zinc oxide coating can also be applied to other material than paper). Electrofax or other zinc oxide paper must also be charged prior to exposure, exposed, and developed. But as the visible image remains on the material, no transfer is required. Liquid electrostatic developers are dispersions of toners in organic solvents of the required characteristics; 'control and fixing agents are part of such developers; the first regulate the electric charge of the toner particles, the second bond the toner image to the support.'"*

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*Victor Strauss, The Printing Industry, Printing Industries of America, Inc., p. 52, 1967.

B. Acceptable Characteristics to Meet Requirements

3. Length of Run

25 minimum copies.

Easily obtainable.

6. Cost

Less than offset (material and labor) for runs up to 25 copies)

Less than offset in limited quantities.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

Easily attainable with present commercial equipment on full size original.

b. Output

6

Obtainable.

9. Scale Variation

±.05 percent.

Within limits of equipment

10. Distortion

±0.1 percent (1/16 inch over a 60-inch dimension).

Within limits of equipment.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Regular high wet strength map paper accepted with new equipment.

12. Start-up Time (1st copy)

5 minutes.

Approximately 5 minutes required for first copy including warm up time.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Unit is moved in a single modular, therefore it is readily set up to be made operational.

b. Weight

5000 pounds maximum (2000 pounds desired).

2500 pounds.

14. Operating Conditions

a. Temperature

40° - 100°F

The system is self-contained so that temperature does not affect the equipment.

15. Process

Utilize dry process - dry to dry.

Dry to dry process.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 36" x 60" required (42" x 60" desired).

Will accept multicolor products up to 18" wide and over 60 " long.

2. Output

Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired).

Monochrome reproduction 18" wide and over 60" long that could be spliced

4. Speed (copies per hour)

60-300

Present equipment can produce 40 copies/hour made by splicing two 18" wide by 60" long pieces together.

5. Image Quality and Color Fidelity

Equal to lithography.

The typical output is good quality but considered at the low end of litho quality.

13. Physical Size

c. Size

120 ft^3.

Volume of approximately 150 ft^3.

D. Unacceptable Characteristics to Meet Requirements

1. Input

b. 70 mm x 100 mm multicolored slides desired.

At the present time, the large equipment will not accept 70 mm x 100 mm slides directly.

14. Operating Conditions

b. Relative Humidity

10 - 95 percent

The high humidity with high temperature does affect the performance of the equipment.

E. Comments

The electrostatic copier technique of reproducing 8-1/2 x 11 sheets of printed material has become commonplace in virtually every office. The industry is now beginning to develop larger pieces of equipment which are capable of producing copies of materials as wide as 18 in. and many feet long. It appears that the capability of extending the width of the drum to accommodate the military map reproduction requirements is within the state-of-the-art.

A large format Electrostatic Image Reproducer (EIR) has been developed for the U. S. Army Engineer Topographic Laboratories (USAETL) as an engineering test model. It was designed to produce short runs of single-color and multicolor maps up to 24 x 36 inches. However a control system for precise registration of colors needs to be incorporated into its design before multicolor maps can be reproduced in register.

F. Representative List of Manufacturers

APECO Corporation
2100 Dempster Street
Evanston, IL

Canon USA, Inc.
Headquarters
10 Nevada Drive
Lake Success, NY 11040

Dennison
72 Ford Avenue
Framingham, MA 01701

Eastman Kodak
343 State Street
Rochester, NY 14650

Horizons Research Incorporated
23800 Mercantile Road
Cleveland, OH 44122

SCM Business Equipment
299 Park Avenue
New York, NY 10017

3-M Company
3-M Center
St. Paul, MN 55101

Xerox Corporation
Rochester, NY 14603

MULTICOLOR REPRODUCTION TECHNIQUES

LITHOGRAPHY/OFFSET

A. Description of Method

The offset lithography method is discussed on page 9. A multicolor sheet-fed offset press consists of individual printing units, each of which prints one color on one side of a sheet as it passes through the press. The usual color progression is first unit yellow, second unit red, third unit blue, and fourth unit black. Of course, the different colors must be separated by a film and plate exposure process to present only the image area desired of each color by each plate.

A multicolor web-fed offset press differs somewhat in that separate printing stations share the same impression cylinder. Webbing around a common drum gives a positive control of paper throughout the printing cycle. While some types have an impression cylinder, others have only blanket cylinders. In this type, the web passes between two blanket cylinders for every printing unit, and the blanket cylinders for one plate cylinder serve at the same time as the impression cylinder for the opposite unit and vice versa.

B. Acceptable Characteristics to Meet Requirements

2. Output

Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color).

This is regarded as standard output material.

3. Length of Run

10-500 copies.

This number of copies is at the low end of the operating range.

4. Speed (copies per hour)

300

This speed is at the low end of the operating range.

5. Image Quality and Color Fidelity

Equal to lithography.

This method is obviously equal to lithography.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

b. Output

8

This is very easily attainable.

c. Black and white color separations up to 24" x 36".

This is considered standard input to this system and requires only that a plate be exposed.

8. Registration

Within 0.005" circle.

This is very easily attainable.

9. Scale Variation

±.05 percent.

This scale variation is within tolerance for standard printing presses.

10. Distortion

±0.1 percent

This parameter is easily met if a dimensionally stable medium is used.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This type of paper presents no real problem when used with a standard offset printing press.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 24" x 36".

This method requires a good deal of equipment, i.e., camera, copyboard and a platemaker, and time to process the material.

b. Color separated black and white 70 mm x 100 mm slides.

This method also requires about the same supportive equipment of a 15X enlarger and platemaker, and time to process the material.

6. Cost

Less than offset (material and labor) for runs up to 300 copies.

Actually this method is equal to and not less than offset cost (see E. Comments).

D. Unacceptable Characteristics to Meet Requirements

12. Start-up Time (1st copy)

5 minutes.

Even with the printing press prepared ahead of time, the first copy would require approximately 10 minutes to print.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Printing presses are much too large and complex to disassemble and then reassemble in 4 to 8 hours.

b. Weight

5000 pounds maximum (2000 pounds desired).

Printing presses in the size range required have a standard average weight of about 10 tons.

c. Size

540 ft^3 (6' x 6' x 15') (120 ft^3 desired).

Printing presses in the size range required are about 1000 ft^3.

14. Operating Conditions

a. Temperature

40-100°F

Printing ink and most papers do not respond well to extreme temperatures.

b. Relative Humidity

10-95 percent

Again, printing ink and most papers do not respond well to extreme humidity.

15. Process

Utilize dry process - dry to dry.

The offset method uses ink and solution to repel ink in areas not to be printed thereby rendering this a wet method.

E. Comments

Proof presses have similar characteristics as those listed above except that they are smaller (300 ft^3), lighter (9000 pounds) and have a correspondingly smaller printing image area (27" x 39" being the biggest commercially available proof press we have found).

Multicolored negatives can cost approximately $200.00 for screened film and plates. If a multicolored original map constitutes the input, the color separation steps which are required to achieve quality reproduction can cost as much as $300.00 per color, or $1,500.00 for a five-color map. 70 mm x 100 mm color separated slides would also cost about the same amount to convert to a full size 24 x 36-inch color map.

F. Representative List of Manufacturers

Baker-Perkins Printing Machinery Corp.
492 W. Wrightwood Avenue
Elmhurst, IL 60126

Consolidated International Corporation
Chicago, IL 60609

Harris-Seybold Company
Cleveland, OH 44105

Heidelberg Eastern, Inc.
Glendale, L.I., NY 10037

MGD Graphic System
2011 W. Hastings
Chicago, IL

Royal Zenith Corporation
2101 Jericho Turnpike
New Hyde Park, NY 11040

Solna Corporation
50 Lafayette Place
Kenilworth, NJ 07033

SCREEN

A. Description of Method

The Screen Process is discussed on Page 14. By using a photosensitized silk or wire screen, multicolored screen printing can be achieved. A sequence of camera separated color negatives, positives, screen exposure is a process which can take up to three weeks to complete for 5-color output. A chemical is used to wash out the unexposed area of the screen and cross-marked registration insures accuracy of the wet-on-dry multicolored printing method. Because wet-on-wet screen printing is not feasible, long drying times must be allowed between applying the different colors. Enamel inks take up to five days to dry. Thus, exposure and drying time makes this process quite time-consuming when high quality is required.

B. Acceptable Characteristics to Meet Requirements

1. Input

Black and white color separations up to 24" x 36".

This is considered standard input to this system and requires only that a plate be exposed.

2. Output

Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color).

This is regarded as standard output material.

3. Length of Run

10-500 copies.

This number of copies is at the low end of the operating range.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This input resolution is standard.

b. Output

8

This is very easily attainable.

9. Scale Variation

±.05 percent.

This scale variation is within tolerances for standard equipment.

10. Distortion

±0.1 percent

This parameter is easily met if a dimensionally stable medium is used.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

This type of paper presents no real problem when used with this process.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

This type of equipment can be easily handled and the unit is not extremely sensitive to movement.

b. Weight

5000 pounds maximum (2000 pounds desired).

Typical average weight is approximately 750 pounds.

c. Size

540 ft^3 (6' x 6' x 15) (120 ft desired).

Typical size is approximately 120 ft^3 for a silk screen press having an image area of 42" x 60".

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 24" x 36".

This method requires a good deal of equipment, i.e., camera, copyboard and screen preparation equipment.

b. Color separated black and white 70 mm x 100 mm slides.

This method also requires about the same supportive equipment of a 15X enlarger and screen processor.

5. Image Quality and Color Fidelity

Equal to lithography.

Only under ideal conditions and with a highly trained operator could this method meet lithographic quality.

6. Cost

Less than offset (material and labor) for runs up to 300 copies.

This method of printing is expensive when the cost of the screen and its processing is considered.

8. Registration

Within 0.005" circle.

This would be difficult to achieve.

14. Operating Conditions

a. Temperature

40 - 100°F

Printing ink and most papers do not respond well to extreme temperatures.

b. Relative Humidity

10 - 95 percent

Again, printing ink and most papers do not respond well to extreme humidity.

D. Unacceptable Characteristics to Meet Requirements

4. Speed (copies per hour)

300

This method is good only up to approximately 100 copies per hour and that does not include drying time required.

12. Start-up Time (1st copy)

5 minutes.

This time requirement could not be met.

15. Process

Utilize dry process - dry to dry.

This is a wet printing method.

E. Comments

It is questionable that this process would be an acceptable technique for reproducing maps in in the fields because of the complexity of reproducing accurate screens and the fact that a wet print that must be dried is produced.

F. Representative List of Manufacturers

Atlas
1733 Milwaukee Avenue
Chicago, IL 60647

Joseph E. Podgor Co., Inc.
P. O. Box 1714
Philadelphia, PA 19105

DIAZO

A. Description of Method

A multicolor diazo copying machine has been designed and is commercially available which is capable of copying in five colors, in one pass, including base color blue or gray. It works on the principle of applying color code pencils or coding liquids onto the reverse side of the original. The treated original, together with a sensitized paper, is put into the multicolor diazo copier which will then automatically produce the desired copies. The original imput may be black ink or pencil on film or on vellum. However, it would be impractical to introduce this technique to large and complex map reproduction because of the time required to prepare the back surface of the original map input.

In addition, it should be noted that, although this technique could have wide applications, the current state-of-the-art development of the equipment has been judged by the project personnel to generate output which is something less than that of lithographic quality.

CHROMIUM DIOXIDE

A. Description of Method

The chromium dioxide process which was described in the single-color portion of this report, could be utilized to reproduce color copies of maps and charts. However, at this time, this process has not been used to make multi-color reproductions. Therefore, this process is not rated or considered in this section of the report.

INK JET

A. Description of Method

The Ink Jet Process, which is discussed on page 36, can also be used for multicolor output. Two color ink jet systems have been built. One has four concentric ink jets which are focused at the same point. The second system uses four ink jet bars with multiple orifices. The original document may be scanned with either a photodiode or laser scanner. The output from the scanner may be used to drive the ink jet directly or the output may be recorded on a magnetic or paper punched tape. When only a single copy of the original is required, the direct drive system is normally used, however, when multiple copies are required the tape system is used.

B. Acceptable Characteristics to Meet Requirements

2. Output

Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color).

Can presently produce full size copies.

3. Length of Run

10-500 copies.

Yes

4. Speed (copies per hour)

300

300 copies are possible with present system.

6. Cost

Less than offset (material and labor) for runs up to 300 copies.

Less than offset lithography because it requires less steps and materials.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

This is easily accomplished with the proper scanner.

b. Output

8

10 L/mm are claimed to be obtainable with 578 jet unit.

8. Registration

Within 0.005" circle.

The system can meet this requirement.

9. Scale Variation

±.05 percent.

The system should be able to stay within this range.

10. Distortion

±0.1 percent

The system should be able to stay within this range.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Yes, almost any substrate is acceptable.

12. Start-up Time (1st copy)

5 minutes.

Less than 5 minutes is normal start-up time.

13. Physical Size

b. Weight

5000 pounds maximum (2000 pounds desired).

Weight is less than 5000 pounds.

c. Size

540 ft^3 (6' x 6' x 15') (120 ft^3 desired).

Volume less than 540 ft^3.

C. Marginally Acceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 24" x 36".

A photodiode or laser scanner is required.

b. Color separated black and white 70 mm x 100 mm slides.

A photodiode or laser scanner is required.

c. Black and white color separations up to 24" x 36".

A photodiode or laser scanner is required.

5. Image Quality and Color Fidelity

Equal to lithography.

Approaches lower end of litho.

15. Process

Utilize dry process - dry to dry.

Output is almost completely dry when it is ejected from the system.

D. Unacceptable Characteristics to Meet Requirements

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

The system cannot be set up within 8 hours.

14. Operating Conditions

a. Temperature

40 - 100°F

60^{o} - 90^{o}F normal operating range.

b. Relative Humidity

10 - 95 percent.

Low humidity required at high temperature in order for equipment to run properly.

E. Comments

Ink Jet printing is primarily being developed by two major companies in this country; Mead Ditital System, Inc. and Gould, Inc. It appears that only the Mead system is capable of producing reproductions in color and in the size and at the rate required.

F. Representative List of Manufacturers

Mead Digital System, Inc.
1368 Research Park Drive
Dayton, OH 45432

ELECTROSTATIC COPIER

A. Description of Method

In addition to the information on electrostatic copiers noted on page 45, Xerox® has developed an electrostatic copier which is capable of reproducing seven colors. In the copying process, the original document sequentially scans three times through different color separating filters. Each color separated image is temporarily placed on the single selenium coated drum from which the corresponding colored toner is transferred onto the paper and heat-fused in place.

A large format Electrostatic Image Reproducer (EIR) which has been developed by Horizons Research Incorporated for the USAETL is discussed on page 49. A production 5-color printer would incorporate five printing modules and would print five colors at 300 copies per hour at one pass through it.

THE XEROX 6500 COLOR COPIER

B. Acceptable Characteristics to Meet Requirements

3. Length of Run

10 - 500 copies.

Easily obtainable.

6. Cost

Less than offset (material and labor) for runs up to 300 copies.

Less than offset in limited quantities.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

Easily attainable with present commercial equipment on full size original.

9. Scale Variation

±.05 percent.

Within limits of equipment.

10. Distortion

±0.1 percent

Within limits of equipment.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Regular high wet strength map paper accepted with new equipment.

12. Start-up Time (1st copy)

5 minutes.

Less than 5 minutes required for first copy.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Unit is moved in a single modular, therefore it is readily set up to be made operational.

b. Weight

5000 pounds maximum (2000 pounds desired).

Meets weight limitation at 1040 pounds.

c. Size

540 ft^3 (6' x 6' x 15') (120 ft^3 desired).

Meets size limitations.

14. Operating Conditions

a. Temperature

40 - 100°F

This system is self-contained so that temperature does not affect the equipment.

15. Process

Utilize dry process - dry to dry.

Dry to dry process.

C. Marginally Acceptable Characteristics to Meet Requirements

5. Image Quality and Color Fidelity

Equal to lithography.

The typical output is good quality but considered at the low end of litho quality.

7. Resolution (L/mm)

b. Output

8

May be obtainable.

8. Registration

Within 0.005" circle.

Too dependent on paper stability and synchronization.

D. Unacceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 24" x 36".

Will accept multicolor products up to 8-1/2" wide x 13-3/4" long.

b. Color separated black and white 70 mm x 100 mm slides.

At the present time, the equipment will not accept 70 mm x 100 mm slides directly.

c. Black and white color separations up to 24" x 36".

At the present time, the equipment will not accept black and white color separations.

2. Output

Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color).

Multicolored reproduction 8-1/2" x 13-3/4" long output copy.

4. Speed (copies per hour)

300

Present equipment can produce 192 five-color copies/hour.

14. Operating Conditions

b. Relative Humidity

10 - 95 percent

The high humidity with high temperature does affect the performance of the equipment.

E. Comments

Although the image size capability of the Xerox 6500 copier is too small to permit it to be considered as a candidate system for this program, the process used by Xerox is technically feasible to reproduce multicolored products and could be expanded to produce output of larger dimensions.

F. Representative List of Manufacturers

Xerox Corporation
Rochester, NY 14603

HORIZONS RESEARCH INCORPORATED ELECTROSTATIC IMAGE REPRODUCER

B. Acceptable Characteristics to Meet Requirements

1. Input

b. Color separated black and white 70 mm x 100 mm slides.

At the present time, the large equipment will accept 70 mm x 100 mm slides directly.

2. Output

Mulitcolor products including overprinted of the previously printed products up to 24" x 36" (5 color).

Multicolored reproduction 24" wide x 36" long.

3. Length of Run

10-500 copies.

Easily obtainable.

6. Cost

Less than offset (material and labor) for runs up to 300 copies.

Less than offset in limited quantities.

7. Resolution (L/mm)

a. Input

10 for full size, 150 for 70 mm x 100 mm slides.

Easily attainable with present commercial equipment on full size original.

9. Scale Variation

±.05 percent.

Within limits of equipment

10. Distortion

±0.1 percent

Within limits of equipment.

11. Printing Medium

Regular high wet strength map paper - option dielectric or photoconductive coated paper.

Regular high wet strength map paper accepted with new equipment, but paper must be precoated.

12. Start-up Time (1st copy)

5 minutes.

Approximately 5 minutes required for first copy.

13. Physical Size

a. Construction

Rugged, readily assembled and disassembled, in about 4-8 hours.

Unit is moved in a single modular, therefore it is readily set up to be made operational.

b. Weight

5000 pounds maximum (2000 pounds desired).

Meets weight limitation.

c. Size

540 ft^3 (6' x 6' x 15') (120 ft^3 desired).

Volume is less than 540 ft^3.

14. Operating Conditions

a. Temperature

40° - 100°F

The system is self-contained so that temperature does not affect the equipment.

15. Process

Utilize dry process - dry to dry.

Dry to dry process.

C. Marginally Acceptable Characteristics to Meet Requirements

5. Image Quality and Color Fidelity

Equal to lithography.

The typical output is good quality but considered at the low end of litho quality.

7. Resolution (L/mm)

b. Output

8

May be obtainable.

8. Registration

Within 0.005" circle.

Too dependent on paper stability and synchronization.

D. Unacceptable Characteristics to Meet Requirements

1. Input

a. Multicolored products up to 24" x 36".

Will not accept multicolor products because a transparency is required.

c. Black and White color separations up to 24" x 36".

This equipment will not except color separations unless they are transparencies.

4. Speed (copies per hour)

300

Present equipment can produce 60 copies/hour.

14. Operating Conditions

b. Relative Humidity

10 - 95 percent

The high humidity with high temperature does affect the performance of the equipment.

E. Comments

The present unit contains only one printing module, which is about 10" x 45" x 50"; consequently, only one color can be printed at a time at 300 copies per hour. Five colors would require five times through this printer and four rewinds.

F. Representative List of Manufacturers

Horizons Research Incorporated
23800 Mercantile Road
Cleveland, OH 44122

DISCUSSION

The purpose of this program was to examine and analyze the state-of-the-art of various applicable printing technologies for possible application in meeting the proposed military requirements for quick reaction/limited quantity, map and chart reproduction capability. These requirements were presented in Table I. The project was divided into two parallel tasks. One task involved the investigation of single-color reproduction processes and the second task involved the review of milticolor processes.

In conjunction with personnel from the U. S. Army Engineer Topographic Laboratories, weighting factors were assigned to each of the requirements, and the various printing techniques were evaluated for their abilities to meet the requirements. The results of these evaluations for the single-color processes are presented in Table II. Although this evaluation procedure was somewhat subjective, the assigned values produced total scores which quite accurately reflect the emperical data collected throughout this program.

A new process called Chromium Dioxide, developed by E. I. DuPont, received the highest rating of all the single-color processes evaluated and is the best candidate for meeting the requirements set forth in this contract. This process is slightly deficient in only two of the fifteen major requirements. These two areas are: its ability to receive a full-size opaque original directly, and its ability to produce lithographic quality output. Presently, a 36-in. wide by 60-in. long reproduction has been obtained by using a 1:1 transparent input. The Chromium Dioxide reproduction equipment can be modified to accept opaque originals from which a reflex image may be placed on the magnetic drum.

The image may also be placed on the drum by scanning full size or 70 mm x 100-mm originals. Over 100,000 copies of an original may be reproduced from a single image transfer to the drum. The output for this equipment cannot be considered equal to top quality lithographic reproductions. However, the copies of a hydrographic chart obtained from the laboratory prototype are very legible and considered to be in the medium range of the lithographic quality scale.

It has been estimated by E. I. DuPont that to perfect a machine system which will produce 36-in. wide black and white output and which will operate in the transparency mode would cost approximately $250,000 to $300,000. To develop a reflex imaging mode using an opaque original would increase that

cost by an additional $250,000 and would require approximately 3/4 to 1 year. To develop a machine which will produce 4-color charts in either the transparency mode or the reflex imaging mode would take 2 years and cost between $1 to 2 million dollars. The biggest problem for color reproduction is to develop an accurate registration system.

Other systems that rank high in this program evaluation include diazo, electrostatic and Ink Jet. However, diazo is considered to be unacceptable because the process will only reproduce a transparent input.

The electrostatic plotters and copiers are excellent candidates. Their only real restriction is that existing equipment will not accept full size 42-in. x 60-in. input and produce full-size output.

Xerox does manufacture an electrostatic copier that will produce 18-in. x 60-in. copies which can be spliced together. It appears that a full-size reproduction machine could be manufactured if the demand were established. Horizons Research Incorporated has produced an experimental electrostatic copier for the U. S. Army Engineer Topographic Laboratories which will accept 70 mm x 100-mm slides and will reproduce 24-in. x 36-in. charts and maps. None of the present equipment will operate at the maximum speed required; however, modifications could be made.

The results of the evaluation of multicolor production techniques are presented in Table III. The number of techniques in this category is more limited. The Ink Jet equipment produced by Mead Technology Laboratory meets most of the major reproduction requirements. As with the single-color system, the input must be obtained with a scanning technique; however, this does not appear to be a major limitation, except for the slow speed. The output from this system is considered acceptable.

Four-color ink jet scanning and printing equipment capable of reproducing 42-in. x 60-in. charts is available at the present time. The only major limitation appears to be with the associated paper handling equipment. It has been estimated that this problem could be resolved with about 18 months of development work. The complete four-color ink jet printing equipment required to reproduce 42-in. x 60-in. charts would cost approximately $838,000.

The only other candidate multicolor reproduction techniques that appear to meet most of the requirements are the electrostatic systems. The Xerox 6500 color copier, for example, is capable of making excellent reproductions of a multicolor map. However, at this time, the maximum size of the output from this system is 8-1/2 x 13-3/4 inches. The Electrostatic Image Reproducer, by Horizons Research, could

be developed so that very acceptable copies would be reproduced. The cost to develop this system is estimated to be approximately $1-1/4 to 1-1/2 million dollars, exclusive of producing multicolored output from multicolored input and would require 1-1/2 years to perfect.

We were unable to obtain cost data from Xerox Corporation for electrostatic equipment of the size required on this project.

CONCLUSIONS

The results of this state-of-the-art study indicate that the Chromium Dioxide process developed by E. I. DuPont is the best candidate for single-color reproduction of full-size charts. Our only reservation about this equipment is its ability to work directly from opaque originals.

The Mead Ink Jet printing equipment operated in a 1:1 scan/print mode is the best candidate for reproducing full-size multicolor charts.

An example of a reproduction technique via satellite, under commercial development, is briefly discussed in Appendix C. It appears that this technique could be used to produce maps and charts at remote locations. Therefore, reproduction processes which could easily be interfaced with satellite communication system should be carefully evaluated before the optimum field equipment is selected.

APPENDIX A

PROPOSED MILITARY REQUIREMENTS FOR LIMITED QUANTITY MAP/CHART REPRODUCTION CAPABILITY

CHARACTERISTICS	REQUIREMENTS	
	Single Color	Multicolor
1. Input	a. Multicolored products up to 36" x 60" required (42" x 60" desired) b. 70mm x 100mm multicolored slides desired	a. Multicolor products up to 24" x 36" b. Color separated black and white 70mm x 100mm slides c. Black and white color separations up to 24" x 36"
2. Output	Monochrome products including overprinting of previously printed products to 36" x 60" (42" x 60" desired)	Multicolor products including overprinting of previously printed products up to 24" x 36" (5 color)
3. Length of run	25 minimum copies	10-500 copies
4. Speed (copies per hour)	60-300	300
5. Image Quality and Color Fidelity	Equal to lithography	Equal to lithography
6. Cost	Less than offset (material and labor) for runs up to 25 copies	Less than offset (material and labor) for runs up to 300 copies
7. Resolution (L/mm)		
a. Input	10 for full size, 150 for 70mm x 100mm slides	10 for full size, 150 for 70mm x 100mm slides
b. Output	6	8

PROPOSED MILITARY REQUIREMENTS FOR LIMITED QUANTITY MAP/CHART REPRODUCTION CAPABILITY (cont'd)

CHARACTERISTICS	REQUIREMENTS	
	Single Color	Multicolor
8. Registeation	Not applicable	Within 0.005" circle
9. Scale Variation	±.05 percent	±.05 percent
10. Distortion	±0.1 percent (1/16 inch over 60-inch dimension)	±0.1 percent
11. Printing medium	Regular high wet strength map paper - option dielectric or photoconductive coated paper	Regular high wet strength map paper - option dielectric or photoconductive coated paper
12. Start-up time (1st copy)	5 minutes	5 minutes
13. Physical size		
a. Construction	Rugged, readily assembled and disassembled, in about 4-8 hours	Rugged, readily assembled and disassembled, in about 4-8 hours
b. Weight	5000 pounds maximum (2000 pounds desired)	5000 pounds maximum (2000 pounds desired)
c. Size	120 ft^3	540 ft^3 (6' x 6' x 15') (120 ft^3 desired)
14. Operating Conditions		
a. Temperature	40-100°F	40-100°F
b. Relative humidity	10-95 percent	10-95 percent
15. Process	Utilize dry process - dry to dry	Utilize dry process - dry to dry

APPENDIX B

Ranking of DMAHC Requirements for
Fast Chart Facsimile Device (5 March 1976)

1*. Multicolor litho copy input up to 36 x 60 inches required, (42 x 60 inches desired).

2*. Output should be litho quality (at least equal to attached sample).

3*. Black and white reproductions up to 36 x 60 inches required, (42 x 60 inches desired).

4*. Maximum distortion ±0.1 percent (1/16 inch over 60-inch dimension).

5*. Quick response (5 minute set-up time) 60-300 copies per hour.

6. Utilize dry process - dry to dry.

7. Regular chart paper output - option dielectric or photoconductive coated paper.

8. Web fed desired, but sheet fed should be considered.

*Requirements 1-5 above are the critical requirements ranked in order of importance.

APPENDIX C

FUTURE FACSIMILE TRANSMISSION TECHNIQUES

It was recently reported in the Graphics Arts Monthly*, September 1976, that for the past year Dow Jones has been transmitting via satellite full-size facsimile pages of the Wall Street Journal from its central production plant in Chicopee, Mass., to a new facility in Orlando, Florida. This satellite is located in a fixed position 22,300 miles above the equator. This process appears to be the most promising new development on the horizon and should be considered in the selection of a reproduction technique for single-color and multicolor maps. It appears that within the next five to ten years, very inexpensive equipment will be available by which an accurate facsimile may be transmitted on a world wide basis via satellite.

The method by which the Wall Street Journal is transmitted is as follows: Full-size pages of the next day's Journal are put together in Chicopee. These page proofs in positive form, are mounted on one of three page-size, drum-type Muirhead scanners, and scanned at a resolution of either 600 or 800 lines per linear inch.

A Dacom 300 Telepress system, using digital data-compression techniques "shrinks" or compresses the data being scanned to permit a shorter transmit time.

The transmission itself utilizes an error codec and wideband modem system devised by Digital Communications Corporation. In simple terms, this system clocks the electronic data impulses produced by the Dacom compressor and converts them into a stream of radio waves.

The radio signal is then transmitted from Chicopee to the satellite via a 33-ft.-wide, dish-type antenna.

As it receives the signal, the distance satellite converts it to a lower frequency to avoid interference, then broadcasts it toward earth in an umbrella-like fashion. In Orlando, a similar earth station and antenna pick up the radio signal, completing the 44,600-mile link. As equipment there changes the radio signal back into electronic impulses, it checks the bits of data for accuracy of transmission using a forward error-correction technique. This helps to filter out any unwanted interference that may have occurred during the transmission.

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* The information contained in this report was extracted from this article.

After checking for accuracy, special reconstructors expand the compressed data stream back into its original form; the resulting impulses drive one of the three drum-type Muirhead output recorders in the Orlando facility, which expose a page-size sheet of film. (Dow Jones modified the Muirhead recorders to use lasers, rather than crater or glow modulator tubes, for exposure. This change permits the use of lith-type film in the recorders instead of the more expensive, high-speed facsimile film.)

After being exposed on the recorder drum, the film is processed automatically and opaqued, then sent to the Orlando plateroom where it is used to expose an additive, wipe-on litho plate.

On the average, it takes about 3 to 3-1/2 minutes to transmit one full-size newspaper page. The actual time for individual pages, however, depends on the scan resolution selected, and the content of the page itself.

It cost Dow Jones about $600,000 for the earth stations in Chicopee and Orlando. In addition, there is a monthly communications charge of $2000. The alternative to this is a land-based microwave telephone communication system which would cost $22,000 for a land-line link on a purely lease basis.

Since we are, in effect, saving money at the rate of about $20,000 per month, we estimate the payback period on the system will be about 30 months. Besides this, we are now getting the equivalent of 50% more transmission capacity over the telephone system, at about 9% of the monthly cost.

Careful attention to error-detection and error-correction techniques, have made facsimile via satellite better than microwave or land-line systems. For example, the telephone cables Dow Jones uses for some of its other links have a bit error rate equivalent to approximately one error per page transmitted.

This high rate requires the receiving electronics to answer back each time an error is detected so that the transmitting equipment could resend corrected data. By contrast, the satellite system has a bit error rate equal to one error for each 50 pages transmitted, and no answer-back circuitry is necessary.

It has been estimated that by 1980 an on-premises satellite receiving station for a newspaper will cost $5,000 or less. Even though most of the information transmitted by these satellites to date is alpha-numerical, graphical transmission is also easily accomplished with the system. For this reason, it appears that the U. S. Army Engineer Topographic Laboratories should seriously consider selecting a single- and multicolor field map reproduction system which will easily interface with a satellite communication system.